APPENDIX A

Rx Model

Loop Reactor Worksheet

Feeds to Loop

Cat feed factor =	250.003	
Cat activity factor =	7	
Catalyst/ethylene =	0.59525	lb/Mlb
Hexene/ethylene =	16.6667	lb/Mlb
Hexene =	1000	lb/h
Catalyst =	35.7147	lb/h
Total ethylene =	60000	lb/h
Isobutane/ethylene =	0.83333	ratio
Total isobutane =	50000	lb/h

Flash Tank

% Hex/%Eth	0.03608	mol/mol
% Ethylene =	5.05372	wt%
% Hexene =	0.54695	wt%
Total Feed =	111000	lb/h
Liquid (Vapor) =	52966.5	lb/h
Isobutane =	50000	lb/h
Ethylene =	2677	lb/h
Hexene =	290	lb/h
PE =	58033.5	lb/h

Inside Loop

% Eth in loop =	5.05	*wt% in liq*
PE (Heat Bal) =	58034	lb/h
Temp =	210	F
Press =	600	psig
% Solids =	37.66810514	wt%
t_{cycle} =	30	s
# of Settling Legs =	4	
Loop Volume =	100	m^3
Settling Leg Diam. =	10	inches
Settling Leg Height =	15	ft
r_{PE} =	0.89	g/cc
BD_{PE} =	0.45	g/cc
Catalyst Productivity =	1624917924	lb PE/lb cat
Temp =	98.9	C
Press =	41.8	atm
r_{slurry} =	0.535	g/cc
% Solids =	22.6	vol%
% C6 =	0.55	wt% in liq
Solids R.T. =	45.9	min
Liquid R.T. =	83.3	min
k (catalyst activity) =	7.0	lb PE/lb cat/min/% Eth.
r_{liq} =	0.431	g/cc
Settling Solids =	36460	lb/h
PE from legs =	58034	lb/h
PE from loop =	0	lb/h
Total out =	376	gpm

Instructions

Make changes to blue text.

May change.

DO NOT make changes to red text.

Click material balance button.

= Calculated but should be input to control model

5

Rx Model Iterative

Loop Reactor Worksheet

Feeds to Loop

Cat feed factor =	250	lbPE/h/min/%eth
Cat activity factor =	7	(micron)^3*lbPE/MMlbcat/%eth/min
Catalyst/ethylene =	0.5952381	lb/Mlb
Hexene/ethylene =	16.666667	lb/Mlb
Hexene =	1000	lb/h
Catalyst =	35.714286	lb/h
Total ethylene =	60000	lb/h
Isobutane/ethylene =	0.8333333	ratio
Total isobutane =	50000	lb/h

Flash Tank

% Hex/%Eth	0.03608	mol/mol
% Ethylene =	5.05	wt%
% Hexene =	0.55	wt%
Total Feed =	111000	lb/h
Liquid (Vapor) =	*52966*	*lb/h*
Isobutane =	50000	lb/h
Ethylene =	2677	lb/h
Hexene =	290	lb/h
PE =	58034	lb/h

PE Balance =	1	lb/h
Hexene Bal =	0	lb/h
Settling Solids Bal =	0	lb/h

Inside Loop

% Eth in loop =	5.05	*wt% in liq*
PE (Heat Bal) =	58033	lb/h
Temp =	210	F
Press =	600	psig
% Solids =	37.67	wt%
t_{cycle} =	30	s
# of Settling Legs =	4	
Loop Volume =	100	m^3
Settling Leg Diam. =	10	inches
Settling Leg Height =	15	ft
r_{PE} =	0.89	g/cc
BD_{PE} =	0.45	g/cc
Catalyst Productivity =	1625	lb PE/lb cat
Temp =	98.9	C
Press =	41.8	atm
r_{slurry} =	0.535	g/cc
% Solids =	22.6	vol%
% C6 =	0.55	wt% in liq
Solids R.T. =	45.9	min
Liquid R.T. =	83.3	min
k (catalyst activity) =	7.0	lb PE/lb cat/min/% Eth.
r_{liq} =	0.431	g/cc
Settling Solids =	36460	lb/h
PE from legs =	58033	lb/h
PE from loop =	0	lb/h
Total out =	376	gpm

Hydrogen

Hydrogen Feed =	8.00	lb/h
Hydrogen Out =	4.00	lb/h
% Hydrogen =	0.0076	wt%
%Hydrogen =	0.2195	mol%
% Hy/% Eth =	0.0210	mol/mol

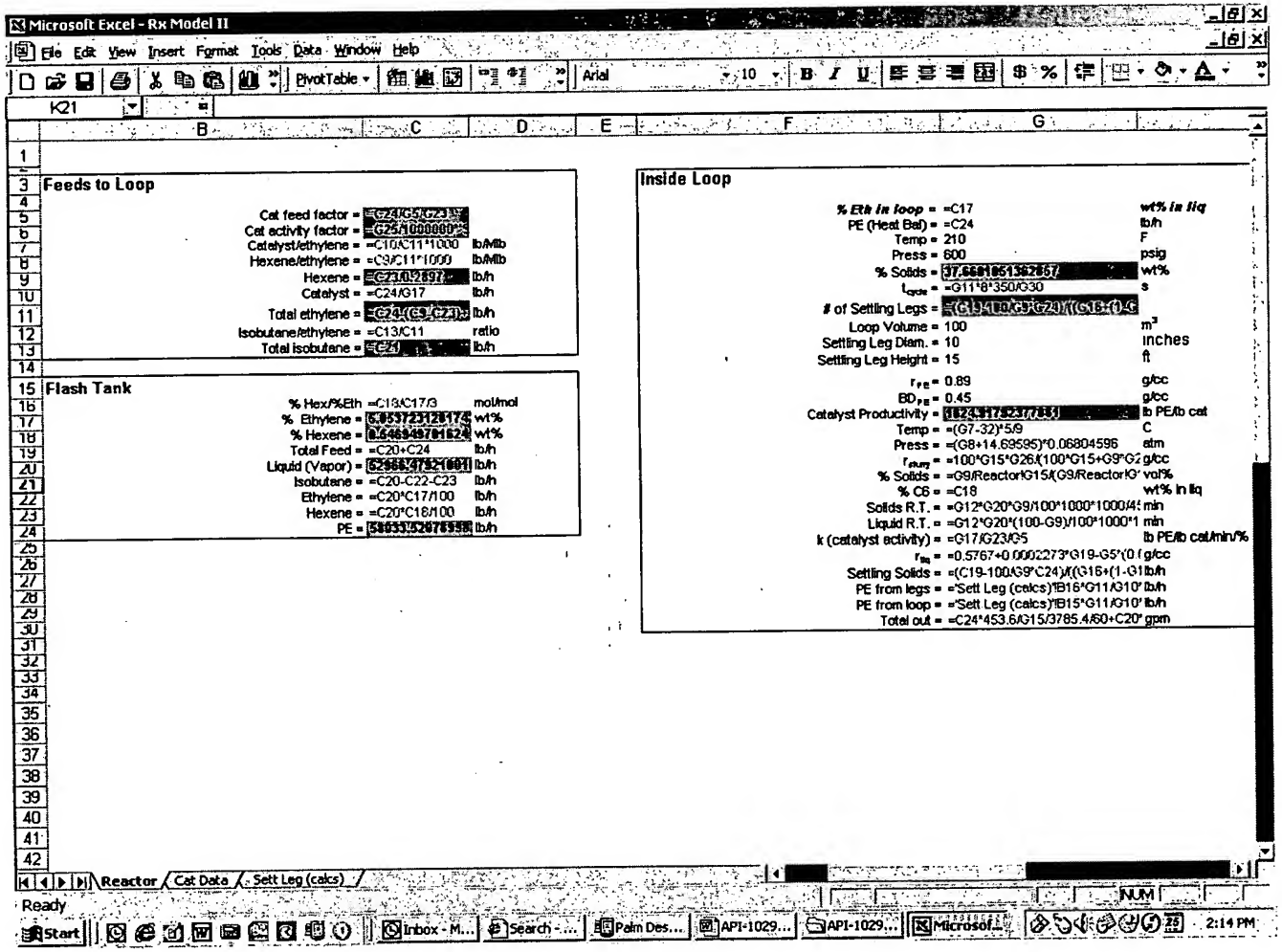
Instructions

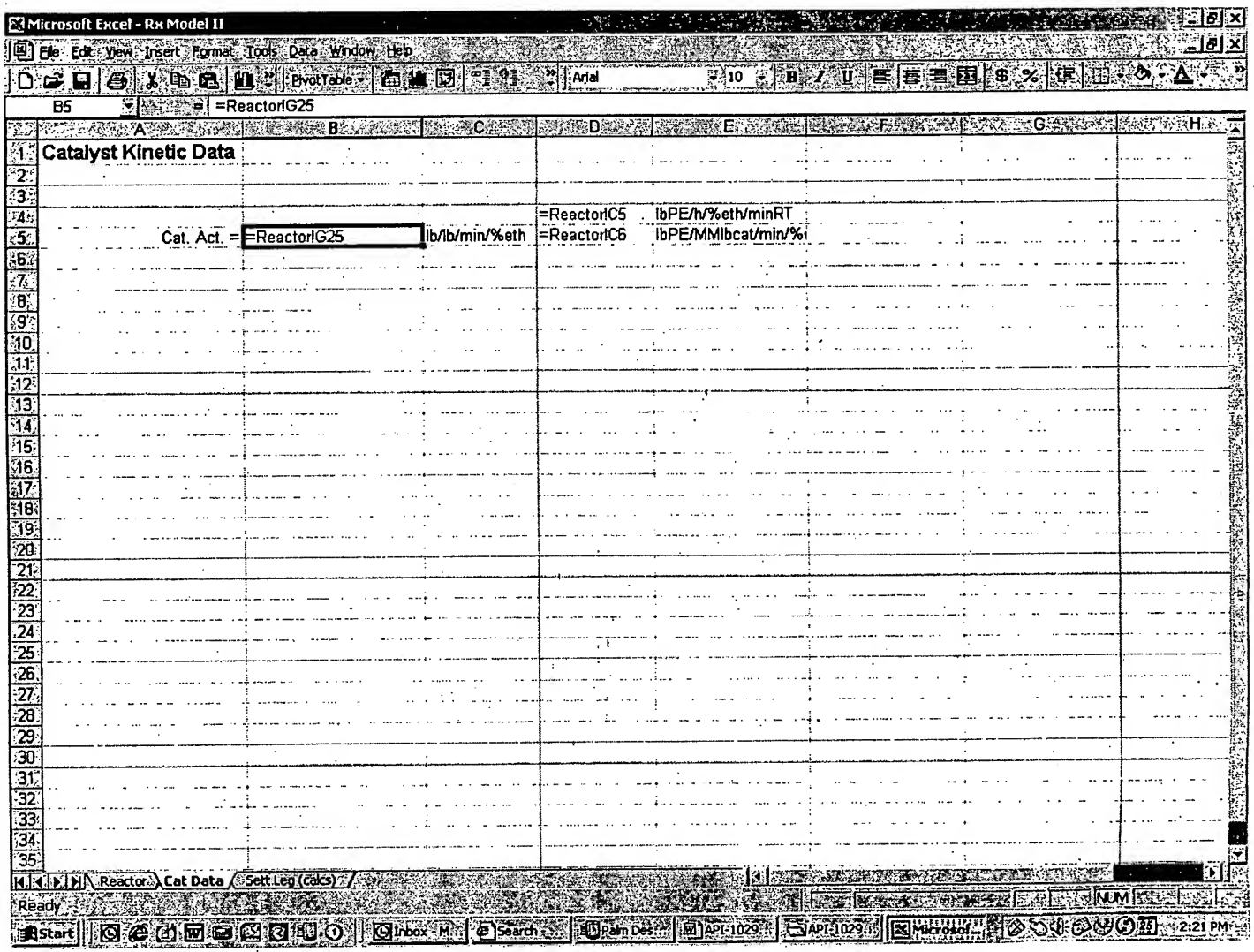
Make changes to blue text (including catalyst below)
May change.
DO NOT make changes to red text.

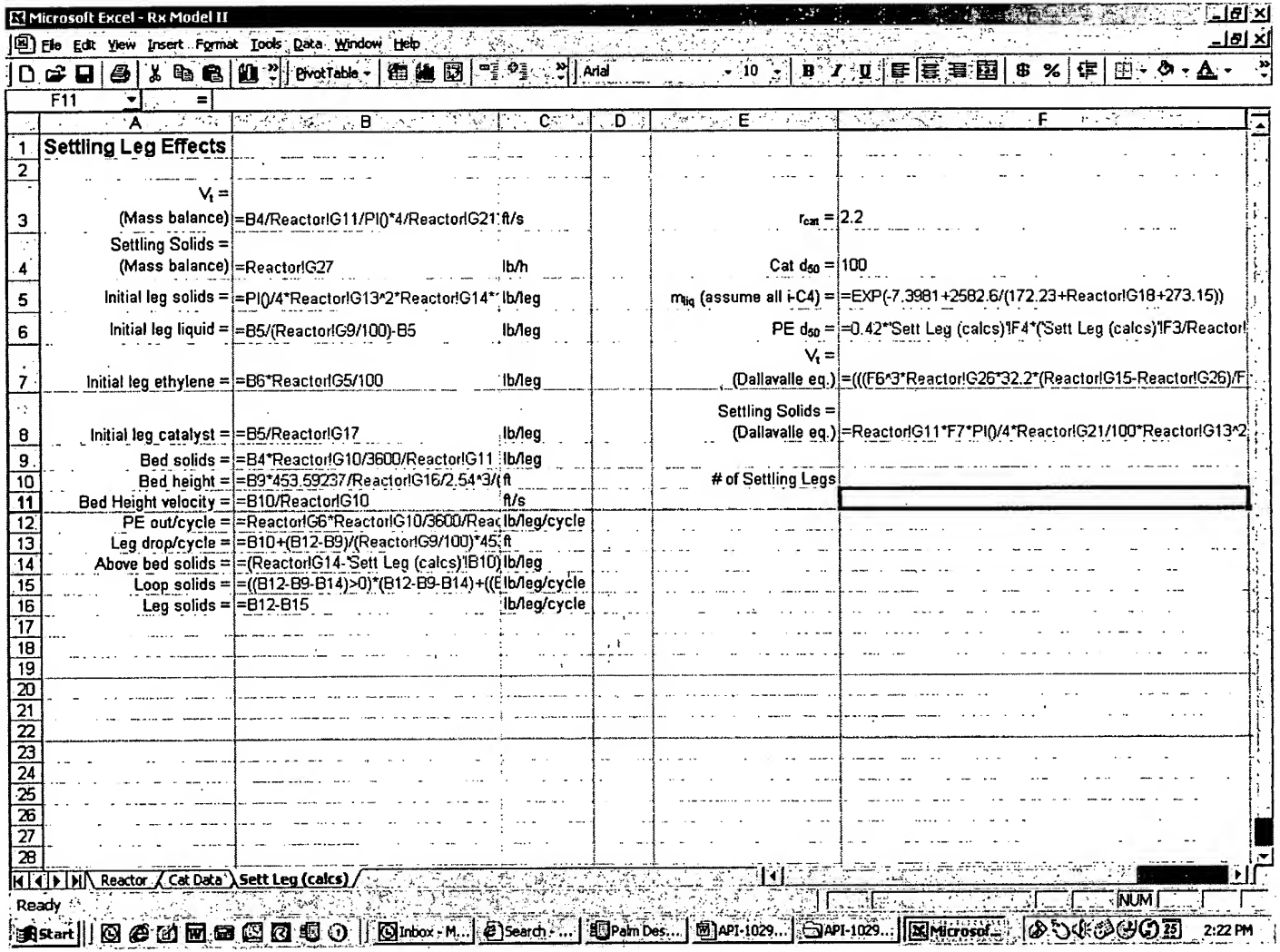
Click material balance button.

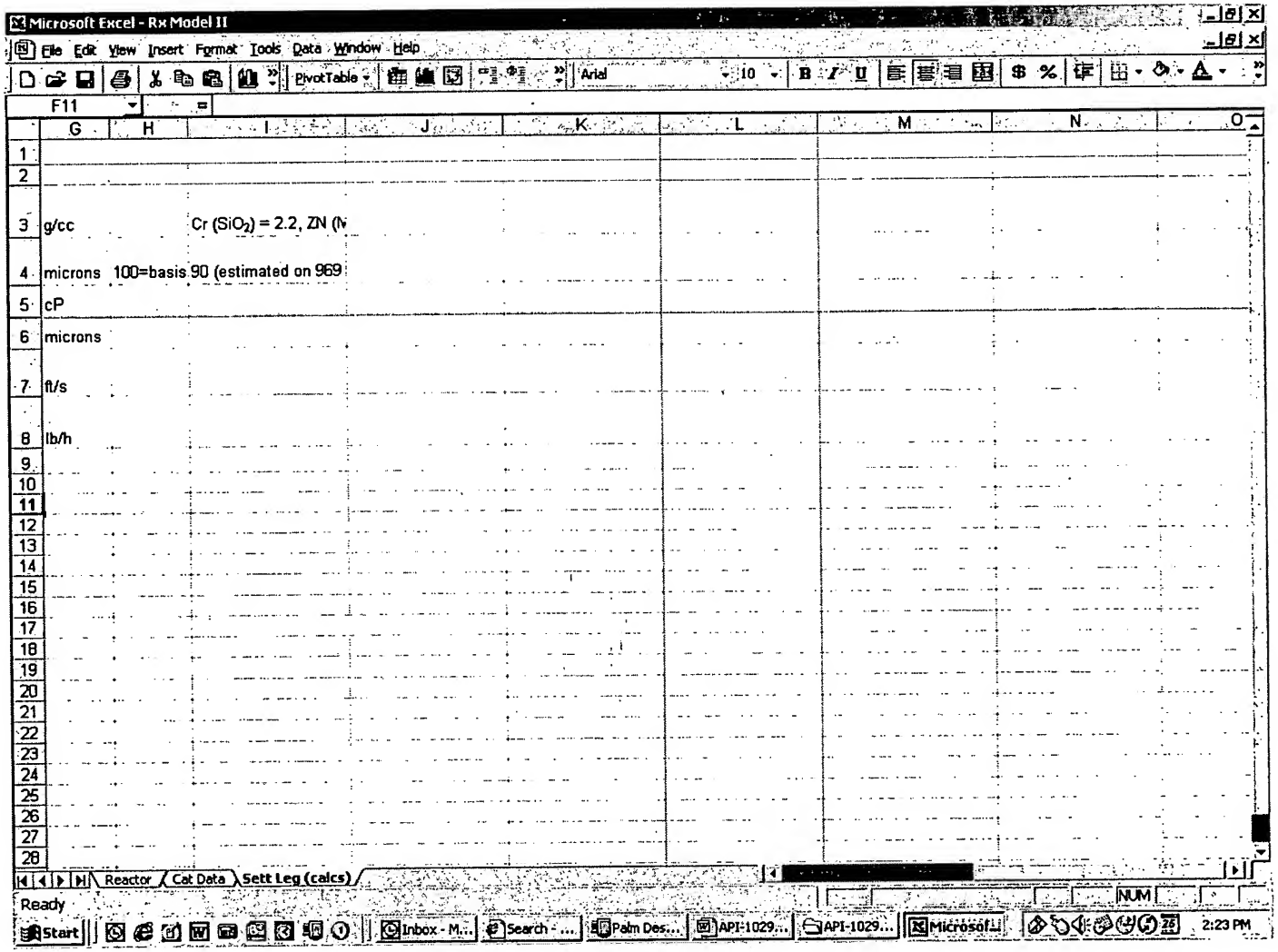
= In Material Balance
= Out of Material Balance

APPENDIX B

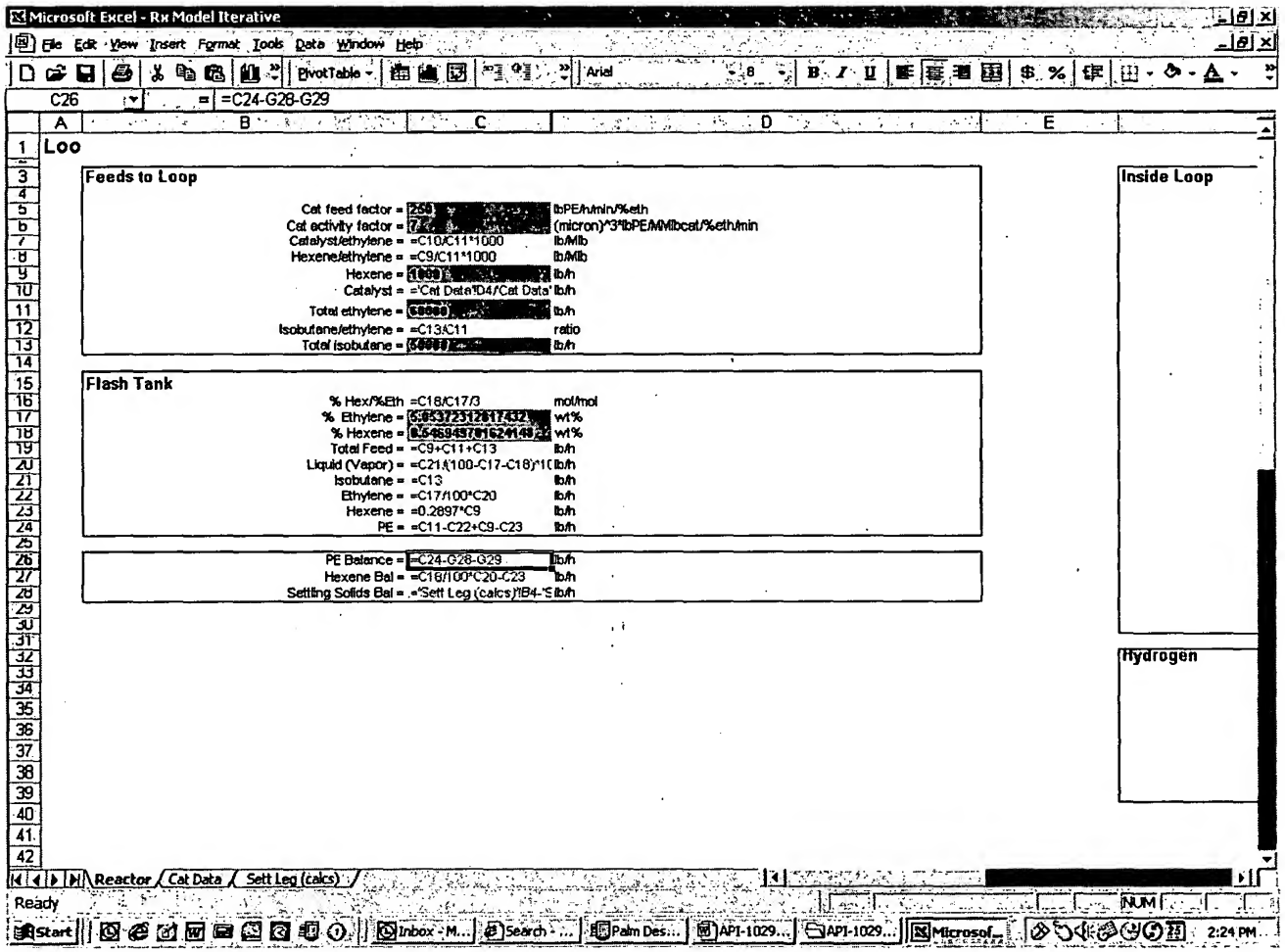

Microsoft Excel - Rx Model II
File Edit View Insert Format Tools Data Window Help
Feeds to Loop
Cat feed factor = =G24/G5/G23*1
Cat activity factor = =G25/1000000*2
Catalyst/ethylene = =C10/C11*1000 lb/Mlb
Hexene/ethylene = =C9/C11*1000 lb/Mlb
Hexene = =C7*0.2897 lb/h
Catalyst = =C24/G17 lb/h
Total ethylene = =G24/(G9-G21) lb/h
Isobutane/ethylene = =C13/C11 ratio
Total isobutane = =G21 lb/h
Flash Tank
% Hex/%Eth =C18/C17/3 mol/mol
% Ethylene = 0.85372312817 wt%
% Hexene = 0.24694978162 wt%
Total Feed = =C20+C24 lb/h
Liquid (Vapor) = 52661.4752 lb/h
Isobutane = =C20-C22-C23 lb/h
Ethylene = =C20*C17/100 lb/h
Hexene = =C20*C18/100 lb/h
PE = 58333.52678558 lb/h
Inside Loop
% Eth in loop = =C17 wt% in liq
PE (Heat Bal) = =C24 lb/h
Temp = 210 F
Press = 600 psig
% Solids = 37.668105136285 wt%
t_{cycle} = =G11*8*350/G30 s
# of Settling Legs = =(G19-100/G9*G24)/((G16+(1-G
Loop Volume = 100 m^3
Settling Leg Diam. = 10 inches
Settling Leg Height = 15 ft
r_{PE} = 0.89 g/cc
BD_{PE} = 0.45 g/cc
Catalyst Productivity = 1824.317523778 lb PE/lb cat
Temp = =(G7-32)*5/9 C
Press = =(G8+14.69595)*0.06804596 atm
r_{slurry} = =100*G15*G26/(100*G15+G9*G2 g/cc
% Solids = =G9/ReactorG15/(G9/ReactorG vol%
% C6 = =C18 wt% in liq
Solids R.T. = =G12*G20*G9/100*1000*1000/4 min
Liquid R.T. = =G12*G20*(100-G9)/100*1000*1 min
k (catalyst activity) = =G17/G23/G5 lb PE/lb cat/min/%
r_{liq} = =0.5767+0.0002273*G19-G5*(0.0 g/cc
Settling Solids = =(C19-100/G9*C24)/((G16+(1-G lb/h
PE from legs = ='Sett Leg (calcs)'!B16*G11/G10 lb/h
PE from loop = ='Sett Leg (calcs)'!B15*G11/G10 lb/h
Total out = =C24*453.6/G15/3785.4/60+C20 gpm
Reactor Cat Data Sett Leg (calcs)
Ready
NUM
Start
Inbox - M... Search - ... Palm Des... API-1029... API-1029... Microsof...
2:14 PM

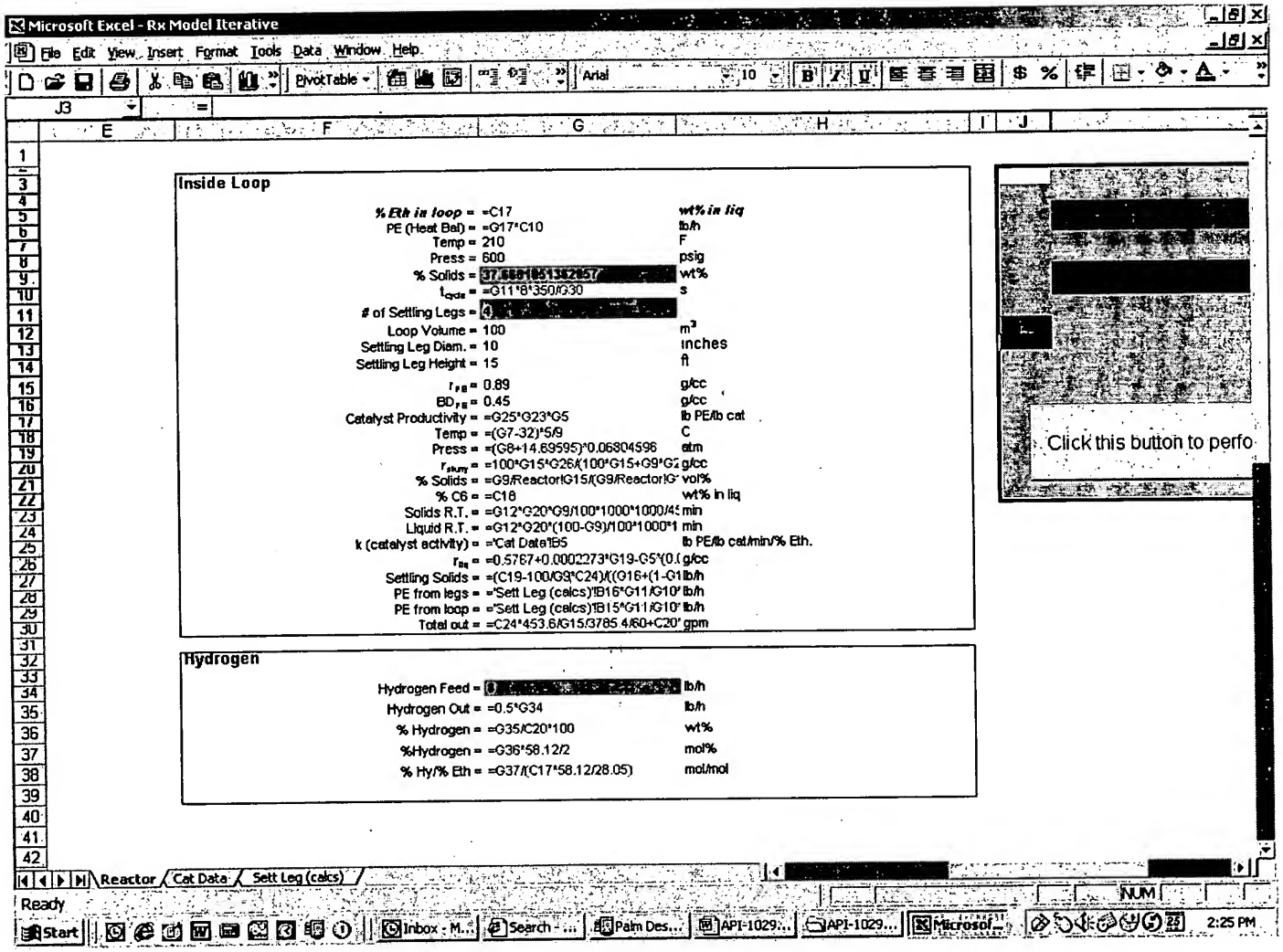

Microsoft Excel - Rx Model II
File Edit View Insert Format Tools Data Window Help
PivotTable
Arial
10
B5
=ReactorIG25
Catalyst Kinetic Data
Cat. Act. =
=ReactorIG25
lb/lb/min/%eth
=ReactorIC5
lbPE/h/%eth/minRT
=ReactorIC6
lbPE/MMlbcat/min/%
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
2:21 PM

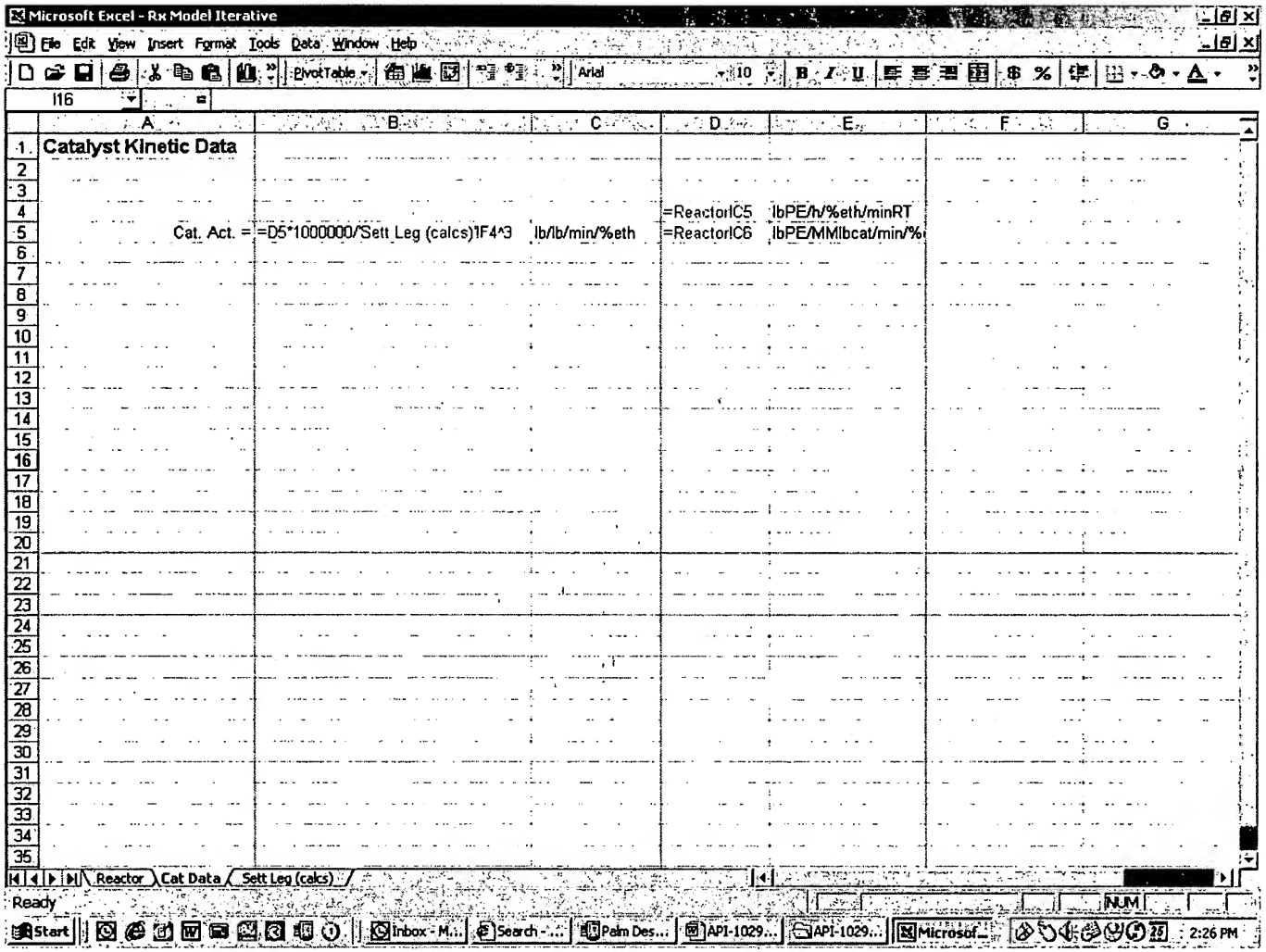

Microsoft Excel - Rx Model II
File Edit View Insert Format Tools Data Window Help
PivotTable
Arial
10
F11
=
Settling Leg Effects
V_t =
(Mass balance) =B4/Reactor!G11/PI()*4/Reactor!G21 ft/s
Settling Solids =
(Mass balance) =Reactor!G27 lb/h
Initial leg solids = =PI()/4*Reactor!G13^2*Reactor!G14* lb/leg
Initial leg liquid = =B5/(Reactor!G9/100)-B5 lb/leg
Initial leg ethylene = =B6*Reactor!G5/100 lb/leg
Initial leg catalyst = =B5/Reactor!G17 lb/leg
Bed solids = =B4*Reactor!G10/3600/Reactor!G11 lb/leg
Bed height = =B9*453.59237/Reactor!G16/2.54^3/(ft
Bed Height velocity = =B10/Reactor!G10 ft/s
PE out/cycle = =Reactor!G6*Reactor!G10/3600/Reac lb/leg/cycle
Leg drop/cycle = =B10+(B12-B9)/(Reactor!G9/100)*45 ft
Above bed solids = =(Reactor!G14-'Sett Leg (calcs)'!B10) lb/leg
Loop solids = =((B12-B9-B14)>0)*(B12-B9-B14)+((E lb/leg/cycle
Leg solids = =B12-B15 lb/leg/cycle
r_{cat} = 2.2
Cat d_{50} = 100
m_{liq} (assume all i-C4) = =EXP(-7.3981+2582.6/(172.23+Reactor!G18+273.15))
PE d_{50} = =0.42*'Sett Leg (calcs)'!F4*('Sett Leg (calcs)'!F3/Reactor!
V_t =
(Dallavalle eq.) =(((F6^3*Reactor!G26*32.2*(Reactor!G15-Reactor!G26)/F
Settling Solids =
(Dallavalle eq.) =Reactor!G11*F7*PI()/4*Reactor!G21/100*Reactor!G13^2
# of Settling Legs
Reactor Cat Data Sett Leg (calcs)
Ready
NUM
Start
Inbox - M... Search - ... Palm Des... API-1029... API-1029... Microsof...
2:22 PM

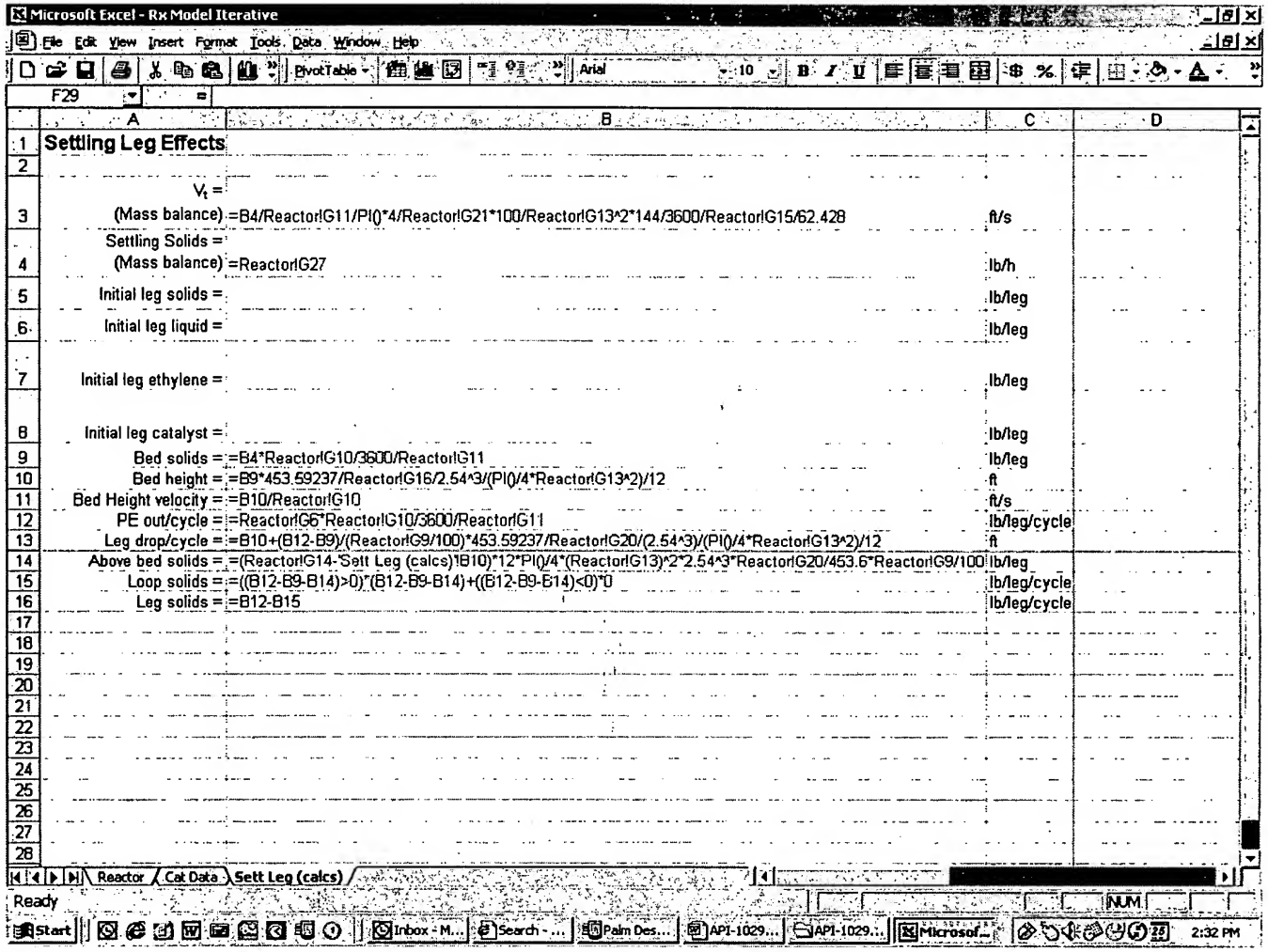

Microsoft Excel - Rx Model II
File Edit View Insert Format Tools Data Window Help
PivotTable
Arial
10
F11
G
H
I
J
K
L
M
N
O
g/cc
Cr (SiO_2) = 2.2, ZN (N
microns
100=basis 90 (estimated on 969
cP
microns
ft/s
lb/h
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
Inbox - M...
Search - ...
Palm Des...
API-1029...
API-1029...
Microsof...
2:23 PM

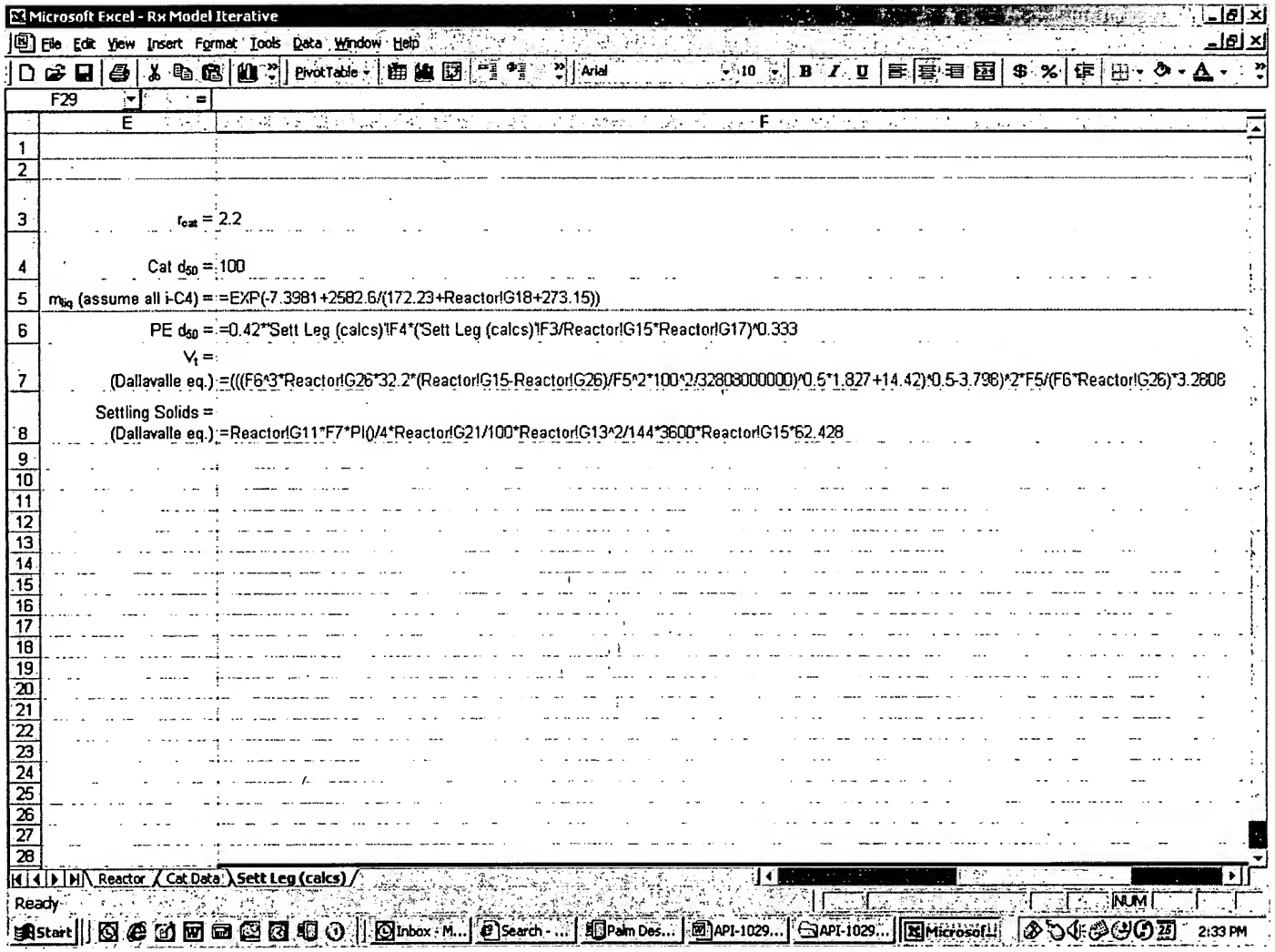
APPENDIX C

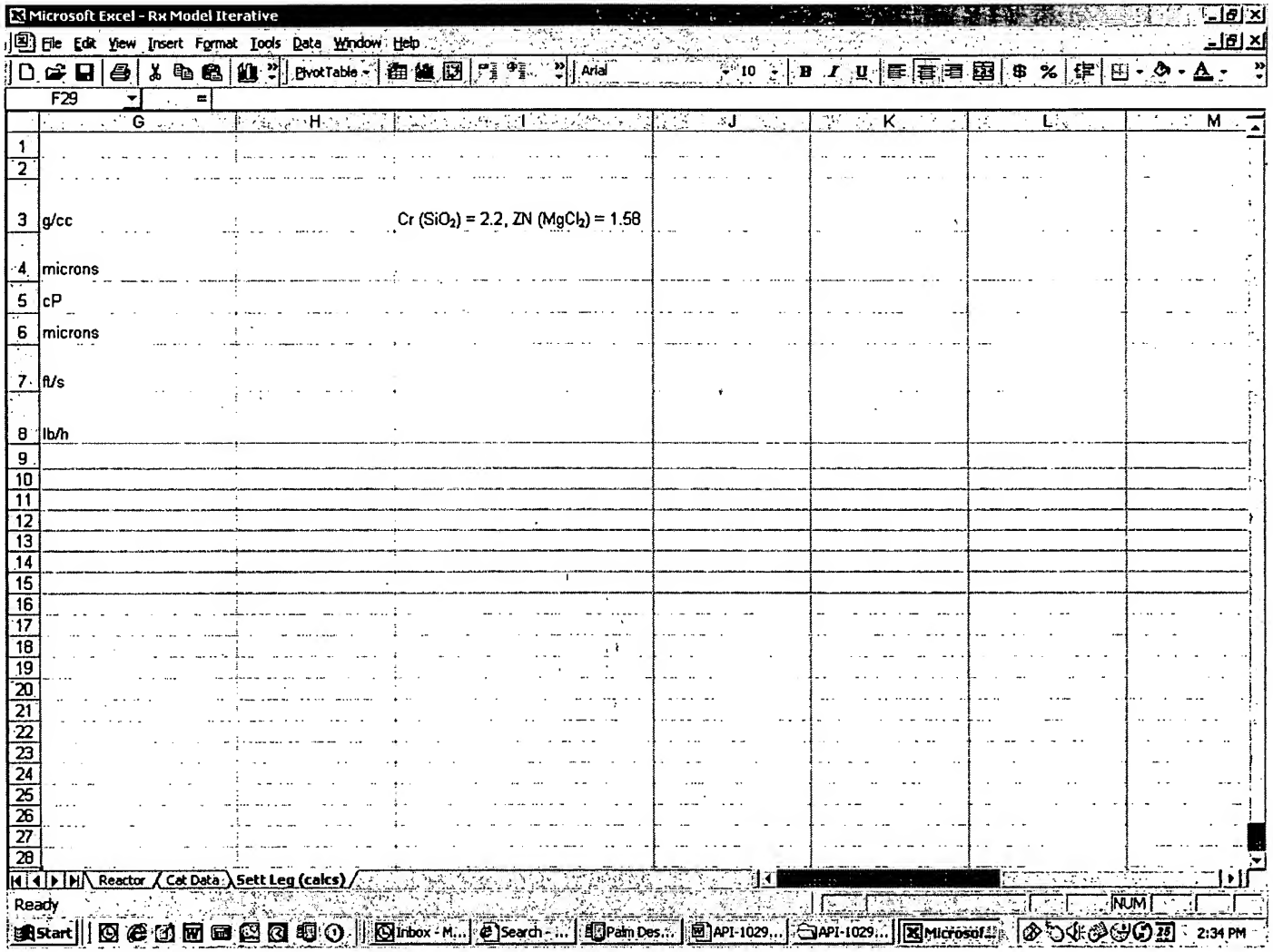

Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
C26 =C24-G28-G29
Loo
Feeds to Loop
Cat feed factor = 250 lbPE/h/min/%eth
Cat activity factor = 722 (micron)^3*lbPE/MMlbcat/%eth/min
Catalyst/ethylene = =C10/C11*1000 lb/Mlb
Hexene/ethylene = =C9/C11*1000 lb/Mlb
Hexene = 1000 lb/h
Catalyst = ='Cat Data'!D4/Cat Data' lb/h
Total ethylene = 60000 lb/h
Isobutane/ethylene = =C13/C11 ratio
Total isobutane = 60000 lb/h
Flash Tank
% Hex/%Eth =C18/C17/3 mol/mol
% Ethylene = 3.853723128117432 wt%
% Hexene = 0.5469457816241455 wt%
Total Feed = =C9+C11+C13 lb/h
Liquid (Vapor) = =C21/(100-C17-C18)*1(lb/h
Isobutane = =C13 lb/h
Ethylene = =C17/100*C20 lb/h
Hexene = =0.2897*C9 lb/h
PE = =C11-C22+C9-C23 lb/h
PE Balance = =C24-G28-G29 lb/h
Hexene Bal = =C16/100*C20-C23 lb/h
Setting Solids Bal = ='Sett Leg (calcs)'!B4-'S lb/h
Inside Loop
Hydrogen
Reactor Cat Data Sett Leg (calcs)
Ready
NUM
Start
Inbox - M... Search - ... Palm Des... API-1029... API-1029... Microsof...
2:24 PM


Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
Inside Loop
% Eth in loop = =C17 wt% in liq
PE (Heat Bal) = =G17*C10 lb/h
Temp = 210 F
Press = 600 psig
% Solids = 37.665851362657 wt%
Loop Volume = 100 m3
Settling Leg Diam. = 10 inches
Settling Leg Height = 15 ft
rPE = 0.89 g/cc
BDPE = 0.45 g/cc
Catalyst Productivity = =G25*G23*G5 lb PE/lb cat
Temp = =(G7-32)*5/9 C
Press = =(G8+14.69595)*0.06804596 atm
% Solids = =G9/ReactorIG15/(G9/ReactorIG wt% in liq
% C6 = =C18 wt% in liq
Solids R.T. = =G12*G20*G9/100*1000*1000/4 min
Liquid R.T. = =G12*G20*(100-G9)/100*1000*1 min
k (catalyst activity) = ='Cat Data'!B5 lb PE/lb cat/min/% Eth.
Settling Solids = =(C19-100/G9*C24)/((G16+(1-G1 lb/h
PE from legs = ='Sett Leg (calcs)'!B16*G11/G10 lb/h
PE from loop = ='Sett Leg (calcs)'!B15*G11/G10 lb/h
Total out = =C24*453.6/G15/3785.4/60+C20 gpm
Hydrogen
Hydrogen Feed = lb/h
Hydrogen Out = =0.5*G34 lb/h
% Hydrogen = =G35/C20*100 wt%
%Hydrogen = =G36*58.12/2 mol%
% Hy/% Eth = =G37/(C17*58.12/28.05) mol/mol
Click this button to perfo
Reactor Cat Data Sett Leg (calcs)
Ready
NUM
Start
2:25 PM


Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
PivotTable
Arial
10
I16
Catalyst Kinetic Data
Cat. Act. =
=D5*1000000/'Sett Leg (calcs)'!F4^3
lb/lb/min/%eth
=ReactorIC5
lbPE/h/%eth/minRT
=ReactorIC6
lbPE/MMlbcat/min/%
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
Inbox - M...
Search - ...
Palm Des...
API-1029...
API-1029...
Microsof...
2:26 PM


Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
F29
Settling Leg Effects
V_t =
(Mass balance) =B4/Reactor!G11/PI()*4/Reactor!G21*100/Reactor!G13^2*144/3600/Reactor!G15/62.428 ft/s
Settling Solids =
(Mass balance) =Reactor!G27 lb/h
Initial leg solids = lb/leg
Initial leg liquid = lb/leg
Initial leg ethylene = lb/leg
Initial leg catalyst = lb/leg
Bed solids = =B4*Reactor!G10/3600/Reactor!G11 lb/leg
Bed height = =B9*453.59237/Reactor!G16/2.54^3/(PI()/4*Reactor!G13^2)/12 ft
Bed Height velocity = =B10/Reactor!G10 ft/s
PE out/cycle = =Reactor!G6*Reactor!G10/3600/Reactor!G11 lb/leg/cycle
Leg drop/cycle = =B10+(B12-B9)/(Reactor!G9/100)*453.59237/Reactor!G20/(2.54^3)/(PI()/4*Reactor!G13^2)/12 ft
Above bed solids = =(Reactor!G14-'Sett Leg (calcs)'!B10)*12*PI()/4*(Reactor!G13)^2*2.54^3*Reactor!G20/453.6*Reactor!G9/100 lb/leg
Loop solids = =((B12-B9-B14)>0)*(B12-B9-B14)+((B12-B9-B14)<0)*0 lb/leg/cycle
Leg solids = =B12-B15 lb/leg/cycle
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
2:32 PM


Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
F29
E
F
r_{cat} = 2.2
Cat d_{50} = 100
m_{liq} (assume all i-C4) = =EXP(-7.3981+2582.6/(172.23+Reactor!G18+273.15))
PE d_{50} = =0.42*'Sett Leg (calcs)'!F4*('Sett Leg (calcs)'!F3/Reactor!G15*Reactor!G17)^0.333
V_t =
(Dallavalle eq.) =(((F6*3*Reactor!G26*32.2*(Reactor!G15-Reactor!G26)/F5^2*100^2/32803000000)^0.5*1.827+14.42)^0.5-3.796)^2*F5/(F6*Reactor!G26)*3.2808
Settling Solids =
(Dallavalle eq.) =Reactor!G11*F7*PI()/4*Reactor!G21/100*Reactor!G13^2/144*3600*Reactor!G15*62.428
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
Inbox - M...
Search - ...
Palm Des...
API-1029...
API-1029...
Microsof...
2:33 PM


Microsoft Excel - Rx Model Iterative
File Edit View Insert Format Tools Data Window Help
PivotTable
Arial
10
F29
=
G
H
I
J
K
L
M
g/cc
Cr (SiO_2) = 2.2, ZN ($MgCl_2$) = 1.58
microns
cP
microns
ft/s
lb/h
Reactor
Cat Data
Sett Leg (calcs)
Ready
NUM
Start
Inbox - M...
Search - ...
Palm Des...
API-1029...
API-1029...
Microsof...
2:34 PM